Winter Solstice in the Ancient Observation of Metonic Cycle

The shortest interval of daily sunlight in our 365-day calendar cycle occurs at winter solstice (most frequently 21 December, day number 355 in our regular year). Coincidentally, a lunar year extends 354.367 days (the sum of twelve complete lunations). So if the lunar year were to start on the first of January, the two would end on the same day (the darkest day of the year coinciding with the end of a lunar year).

And since the 19-year Metonic Cycle marks the recurrence of lunar phases on the same day of the year, winter solstice would prove the ideal day in the solar cycle from which to initiate Metonic counts.

Recognizing this possibility & aware that the earliest explicit record of the 19-year cycle has been dated to 432 BC, I wondered whether this potential calibration might not add insight into its discovery & use.

Since the Metonic Cycle extends 19 years, it would only be the final year in the cycle which converged with winter solstice. But the night of convergence – anticipated for 19 long years by those observing the sequence – would be an auspicious occasion for ceremony & festivity. The converging 'demise of the diminishing year' with 'the death of the moon in its extended cycle', would promptly give way to the welcome birth of a bountiful new year on the very day the moon embarked on another of its inconspicuous 19-year marathons.

Yet for 'the final solar-year interval' (of the 19 such intervals in a Metonic Cycle) to coincide on the 355th day of our regular calendar year, with 'the end of a 354.367-day lunar year', the lunar year must begin January first.

In other words, if my suspicion is correct, the hypothetical ancient convergence of Metonic Cycle with winter solstice, might arguably have been what led to the conception of 'the start of a calendar year on (what we now call) the first of January' – *ie,* a full lunar-year before winter solstice. Not immediately in practice (as we know historically), but possibly as the seed of the subsequent Julian 'innovation'.

The lunation, it bears noting, ends with the descent of waning crescent, while a new lunation begins with the dark night known as New Moon.

To collate the evidence, I tabulated extracts from Fred Espenak's *Six Millennium Catalog of Phases of the Moon (2000 BCE to 4000 CE)* online at *Astropixels.com,* looking for calendar years not only where New Moon fell on, or very close to, 22 December, but also where the beginning of 'the interval of a Lunar Year' fell on, or close to, January first. I began with the year 776 BC when the predecessor to the later 19-year calendar (the 8-year calendar) was purportedly introduced.

New Moon on December			**Lunar Year starts on January**	
774 BC	(12:36)	22	1	(20:19)
755	(11:18)	22	1	(21:27)
736	(03:15)	22	2	(19:56)
717	(11:49)	22	2	(11:26)
698	(20:06)	21	1	(19:47)
679	(11:28)	21	1	(04:17)
660	(09:53)	21	1	(20:05)
641	(10:37)	22	1	(18:45)
622	(08:09)	22	1	(19:26)
603	(22:11)	21	1	(16:42)
584	(05:50)	21	2	(06:18)
565	(15:16)	21	1	(13:50)
546	(08:26)	21	31	(23:33) December 547 BC
527	(07:42)	21	31	(17:06) December 528
508	(08:01)	21	1	(16:34) January
489	(04:01)	22	1	(16:48)
470	(16:10)	21	1	(12:30)
451	(23:23)	20	1	(00:15)
432	(10:15)	20	1	(07:26)

Example: New Moon fell on 22 December 774 (at 12:36 pm) initiating a new lunar year (& potentially a new Metonic Cycle); while a full lunar year preceding that day, began 1 January 774 (at 20:19 pm).

Apart from the apparent discrepancies in the list, it's remarkable that the cycle of these convergences (or near convergences) culminates in the very year that Metonic Cycle was first noted. Which may attest to an element of predictability in the study, given the coincidence.

The apparent discrepancies (12 of the 19 years listed, falling on an earlier calendar day) are in part explained by their times on the clock, as well as the fact that New Moon regularly appears to extend two nights when observed empirically without a telescope. It further bears noting that winter solstice can also fall on the 20th or 21st of December (& less frequently even on the 23rd).

Another mitigating factor in settling on a potential date of inception for this putative observance, is the emergence of New Moon on 22 December in four other years* within the window of opportunity. Each of the four, falls eight years from the outset of a Metonic Cycle:

New Moon on December			**Lunar Year starts on January**	
546	(08:26)	21	31	(23:33) December 547
538*	(19:52)	22	2	(16:12) January
527	(07:42)	21	31	(17:06) December 528
519*	(15:31)	22	2	(04:17) January
508	(08:01)	21	1	(16:34)
500*	(15:46)	22	3	(00:16)
489	(04:01)	22	1	(16:48)
470	(16:10)	21	1	(12:30)
451	(23:23)	20	1	(00:15)
443*	(18:48)	22	2	(17:18)
432	(10:15)	20	1	(07:26)

Considering that the 19-year cycle is roughly comprised of an 8-year cycle & an 11-year cycle (or, alternately, two 8-year cycles & a 3-year cycle) – all recognized intervals of extended calendar measure in the ancient world – & that the prevailing calendar in use in Greece prior to the disclosure of the Metonic Cycle was the 8-year calendar, these four 8-year conjunctions may afford additional insight into when the 19-year cycle was identified. The prospect of solstice conjunction may also provide a further clue for the Antikythera mechanism project.

Among my earlier reports in this field – which are freely accessible both at Internet Archive & ResearchGate – is a concise introduction to the key discovery that ultimately led to the present speculation: *The Lunar Basis of Myth & Symbol.* Two far more extensive studies which have too many footnotes to follow easily online, are available in paperback editions at the address below.

Realizing that only seven of the nightly appearances of the moon are reliably identifiable on sight, I discovered that these seven spectres were individually ascribed both names & symbols in ancient cultures – characteristic lunar identities which embody the key to greater understanding of the myths & rites of those cultures.

The seven identifiable spectres are: waxing crescent (third night); waxing half-moon (9); first full moon (15); second full moon (16); first waning phase (17); waning half-moon (23); waning crescent (29). Spectres which fall between them are difficult to identify accurately.

For example it's harder for an observer to conclusively identify which precise night in the cycle any other concave waxing spectre occupies, particularly if the earlier spectres in that cycle have been obscured by cloud. The crescentine spectres appearing on the fifth & sixth nights of the cycle can prove indistinguishable, making it hard to determine which night of the lunation it actually is (without another point of reference, such as the observation of preceding spectres).

Thus ancient observers concerned with an accurate measure of time, arguably settled on the seven independently identifiable spectres in their efforts to reliably delimit the complexities of lunar mechanics, in the interest of perfecting a perpetual calendar – a theoretical lunisolar measure based on detailed & sustained observation.

It bears noting that those complexities are so great that no one had ever managed a comprehensive analysis with reliable accuracy, before 1919 & the publication of Ernest William Brown's monumental three-volume *Tables of the Motion of the Moon* (Yale & Oxford).

Synodic Lunar Cycles

A	mean lunar month: a single lunation	0029.530588 days
B	mean lunar year: 12 lunations	0354.367056 days
C	18.03-year eclipse cycle: 223 lunations *aka* Saros cycle	6585.321124 days
D	18.6-year course cycle: 230 lunations *aka* Nodal Regression round	6792.03524 days
E	19-year phase cycle: 235 lunations *aka* Metonic cycle	6939.68818 days

Plugging the appropriate symbol of the observed spectre into its correlative square in a blank solar calendar grid, would allow observers to track the moon reliably over lengthy intervals of time, leading to the isolation of an extended measure such as the 19-year Metonic Cycle, in which the phases of the lunation recur on the same day of the year.

Note on dates: tabular years abide by an 'astronomical dating system' which includes the year "zero" between 1 AD & 1 BC in our 'commonly observed chronology' (which does not). In part, this means that the tabular year 432 BC, for example, is actually 433 BC in historical reckoning. A negligible complication however for the coincidence noted above, in that it would not be unreasonable to assume that the earliest historical record of Metonic Cycle (432 BC) might have taken time to appear, following the last astronomically-dated convergence in my list (20 December 433 BC).

Nick Drumbolis
lettersbookshops@gmail.com [plural]

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letters bookshop 647 Simpson St Thunder Bay Ont Canada p7c 3j9